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**STRUCTURAL STEEL ALTERNATIVE**
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- (56) Prior Art Documents  
**AU 77308/91**  
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**FR 2273129**
- (57)

A characteristic of the invention is illustrated clearly in Figs 2 and 3, which show a beam 20 with a Z-shaped upper chord 21 extending transversely, but as shown in Fig 2 there is no transverse lower chord so that stiffness against deflection is imparted mostly by the upper chords 21. This allows some flexibility in the transverse beams 20, but each of the longitudinal trusses 22 has an upper chord 23 and a lower chord 24, as illustrated in Fig 3. Thus the relatively shorter span 22 of the transverse members is bridged by rigid trusses and the relatively longer span 20 bridged by flexible beams, this giving the optimum facility for accommodating variations in tolerances, dimensions and shape occurring in manufacture, erection, ground movement, temperature differentials and other factors.

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1. A space frame useable as an alternative to hot rolled structural steel in building construction,  
comprising an array of relatively flexible beams each having an upper chord and struts, but no lower chord,  
an array of relatively rigid trusses intersecting said beams, and each said rigid truss having upper and lower chords and intermediate struts,  
and joining means joining the struts and chords at node points.

**AUSTRALIA  
PATENTS ACT 1990**

**COMPLETE SPECIFICATION**

**FOR A STANDARD PATENT**

***ORIGINAL***

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**Invention Title:** "Structural Steel Alternative"

**Details of Associated Provisional**

**Application No:** PM 6163 dated 8th June, 1994

The following statement is a full description of this invention, including the best method of performing it known to the applicant.

This invention relates to a structural steel alternative, being a space frame where the selection and deletion of members provide a structure the rigidity of which in the direction perpendicular to the span (transverse direction) is significantly reduced but wherein structural capacity is equivalent to a structural steel frame of comparable spans.

Space frames are very well known and are in common use. In prior art, each space frame has intersecting trusses with upper and lower chords interconnected at node points by struts, some at least of which function in the two trusses. They are particularly useful for structures exposed to public view and where aesthetics is of paramount concern, for example in supporting glass atriums.

The struts and chords are usually of tubular material and a space frame uses material more efficiently than a frame constructed of hot rolled structural steel sections. However, the space frames require a great deal of assembly because of the large number of interconnecting joints and these are usually welded or are secured together by means of securing members, such as bolts, while in some instances the ends of the tubular members are flattened and are bolted. In that regard, reference may be made to Australian Patent Application No 46104/93 in the name of Mackenzie, the closest prior art known to the Applicant.

In all instances known to the Applicant, interconnecting joints have been rigid, and also the longitudinal and transverse trusses have comprised three chords. As a consequence of this, the relatively light space frames are very rigid in all directions, since they are rigid in both transverse and longitudinal directions. They are frequently used over large areas. Consequently the footing support spacing in the transverse and longitudinal direction should be comparable in order for the structure to be most efficient, but any differential settlement of the footings will induce additional stress within the frame.

However, some soils are more dimensionally unstable than others, and many instances occur wherein it is not possible to ensure no differential occurs between footing heights or spacings.

5 The main object of this invention therefore is to provide improvements in design, construction and fabrication processes to produce a space frame which possesses a degree of flexibility, and may be used as an alternative to those structures traditionally made from structural steel.

Briefly, in this invention, a space frame comprises a plurality of relatively flexible beams which are intersected by a plurality of relatively rigid trusses, the  
10 more flexible beams each comprising a continuous chord. Spacing of the chords may be determined by cladding material. The trusses each comprise tubular members in both the shared chords and diagonals. The spacing and depth of the trusses are engineered to carry the required load for a given span. This configuration can result in the diagonal members having a shallower  
15 incline than conventional trusses.

With this invention, therefore, there is much greater stiffness in the trusses than in the beams, whereby the beams are free to deflect by small amounts without imposing excessive structural stresses on the struts which comprise them. The space frame of this invention still retains its capacity to act  
..... 20 as a diaphragm, eliminating the use of cross-bracing which is otherwise used in a conventional structural steel frame.

.....  
Another contributing factor in these space frames which, when not welded, use bolts where the struts are interconnected, as in the aforesaid Australian Patent Application of Mackenzie. In the Mackenzie specification  
25 there is illustrated the use of four bolts at each interconnecting point, and these impart a considerable rigidity which inhibit relative rotational movement between adjacent struts, and also will not allow the transverse beam spacing to be different from the longitudinal truss spacing. When this invention utilises a

shallower inclination of the diagonal members, a greater shear is imposed at the connections than these are capable of supporting.

In another embodiment of the invention, the ends of the struts are interconnected at node points in most if not all of interconnections by means of bolts passing through pressed profiled apertures, there being one bolt only at each node point. Even though the bolts can be tightened quite considerably, nevertheless under extreme conditions there is some degree of freedom of rotation which is likely to occur before overstressing the material of the struts.

A preferred embodiment of the invention is described hereunder in some detail with reference to and is illustrated in the accompanying drawings, wherein:

Fig 1 is a fragmentary perspective drawing of a building frame constructed in accordance with this invention;

Fig 2 is a fragmentary side elevation of a beam;

Fig 3 is an end elevation of Fig 2, and therefore a side elevation of a rigid truss;

Fig 4 is a top view of Fig 3;

Fig 5 is a sectional drawing through a node point showing the manner in which the ends of the struts may be interconnected with a single bolt; and

Fig 6 is a perspective view of a strut end.

Referring firstly to Figs 1 to 4, a building 10 has a frame which is constructed solely of space frames 11, each of which comprises main struts 12 which are interconnected at node points 13, each node point 13 having a central bolt 14 (Fig 5) passing through apertures 15 in flattened ends 16 of tubular struts 12. However, as illustrated best in Fig 6, each flattened end 16 is provided with a truncated conical portion 17 extending in one direction, and up-turned spacer flanges 18 in the opposite direction. With this arrangement, the truncated conical portions 17 interengage one another as best illustrated in Fig

5, and the spacings which result between adjacent flattened ends 16 are accommodated by the spacer ribs 18 which are very small but which bear against faces of adjacent flattened ends 16 of the joining struts 12.

A characteristic of the invention is illustrated clearly in Figs 2 and 3, which show a beam 20 with a Z-shaped upper chord 21 extending transversely, but as shown in Fig 2 there is no transverse lower chord so that stiffness against deflection is imparted mostly by the upper chords 21. This allows some flexibility in the transverse beams 20, but each of the longitudinal trusses 22 has an upper chord 23 and a lower chord 24, as illustrated in Fig 3. Thus the relatively shorter span 22 of the transverse members is bridged by rigid trusses and the relatively longer span 20 bridged by flexible beams, this giving the optimum facility for accommodating variations in tolerances, dimensions and shape occurring in manufacture, erection, ground movement, temperature differentials and other factors.

The "Z" purlins 21 function not merely as upper chords but also as continuous purlins over the nodes 13 which has the effect of substantially eliminating torsion and sharing load across adjacent truss struts.

A consideration of the above embodiment will indicate that the structure of Fig 1 is more flexible than prior art structures comprising complete trusses in both longitudinal and transverse directions, thereby greatly reducing the internal stresses generated by ground movement. That is the main thrust of this invention. However, almost equally as important is the use of the single bolts 14 in each node point of each truss, and the self-aligning and interengagement of the frusto-conical portions of the various truss ends which are secured together by the bolt assembly 14. Since many of the trusses are the same length in each of only a few patterns, the production costs can be very low and the assembly costs also very low. It is often possible to erect a space frame structure from preformed struts and chords which can be transported from

factory to site by regular transport means. Fig 5 shows the function of the spacer ribs 18 which apply pressure over spaced areas of the flattened ends 16 of abutting trusses. The spacer flanges 18 also stiffen the ends of the struts 12 where they might otherwise bend, so that the structure can better resist increased forces which are imposed by the small inclination angles, and this is further assisted by firm clamping of the frusto-conical portions 17.

The tooling required to prepare the struts 12 is exceedingly simple and readily applied with very simple jigs attached to presses, although special machines can be constructed for the purpose of forming the struts and deforming the lower flanges of the Z section purlins, as shown in Fig 5. Fig 5 also illustrates cladding 25, the span of which can determine beam spacing.

While the beam 20 has only one chord, it can of course be provided with a fastening timber or other fastening means extending along it, which does not perform a structural purpose.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A space frame useable as an alternative to hot rolled structural steel in building construction,  
comprising an array of relatively flexible beams each having an upper  
5 chord and struts, but no lower chord,  
an array of relatively rigid trusses intersecting said beams, and each  
said rigid truss having upper and lower chords and intermediate struts,  
and joining means joining the struts and chords at node points.

2. A space frame according to claim 1 wherein said beam  
10 upper chords comprise purlins, each said purlin having a flange connected to  
ends of said struts at some of said node points.

3. A space frame according to claim 2 wherein said beam  
upper chords are of general 'Z' shape in cross-section.

4. A space frame according to claim 1 or claim 2 wherein  
15 each said strut is generally tubular in cross-section, but flattened at its ends,  
and said ends comprise frusto-conical surfaces which abut similar frusto-  
conical surfaces of other said struts at node points.

5. A space frame according to claim 4 wherein said flattened  
ends of the tubular struts have edges deformed into onstanding spacer ribs  
.... 20 which bear against flattened ends of other of said struts at said node points.

6. A space frame according to either claim 4 or claim 5  
wherein each said node point comprises a central bolt which clamps a said  
frusto-conical surface of an end of each said strut at that said node point to the  
frusto-conical surface of an adjacent said strut.

25 7. A space frame according to either claim 4 or claim 5 further  
comprising cladding overlying and secured to said beams, the cladding span  
determining beam spacing.

8. A space frame substantially as hereinbefore described with reference to and as illustrated in the accompanying representations.

DATED this 8th day of June, 1995

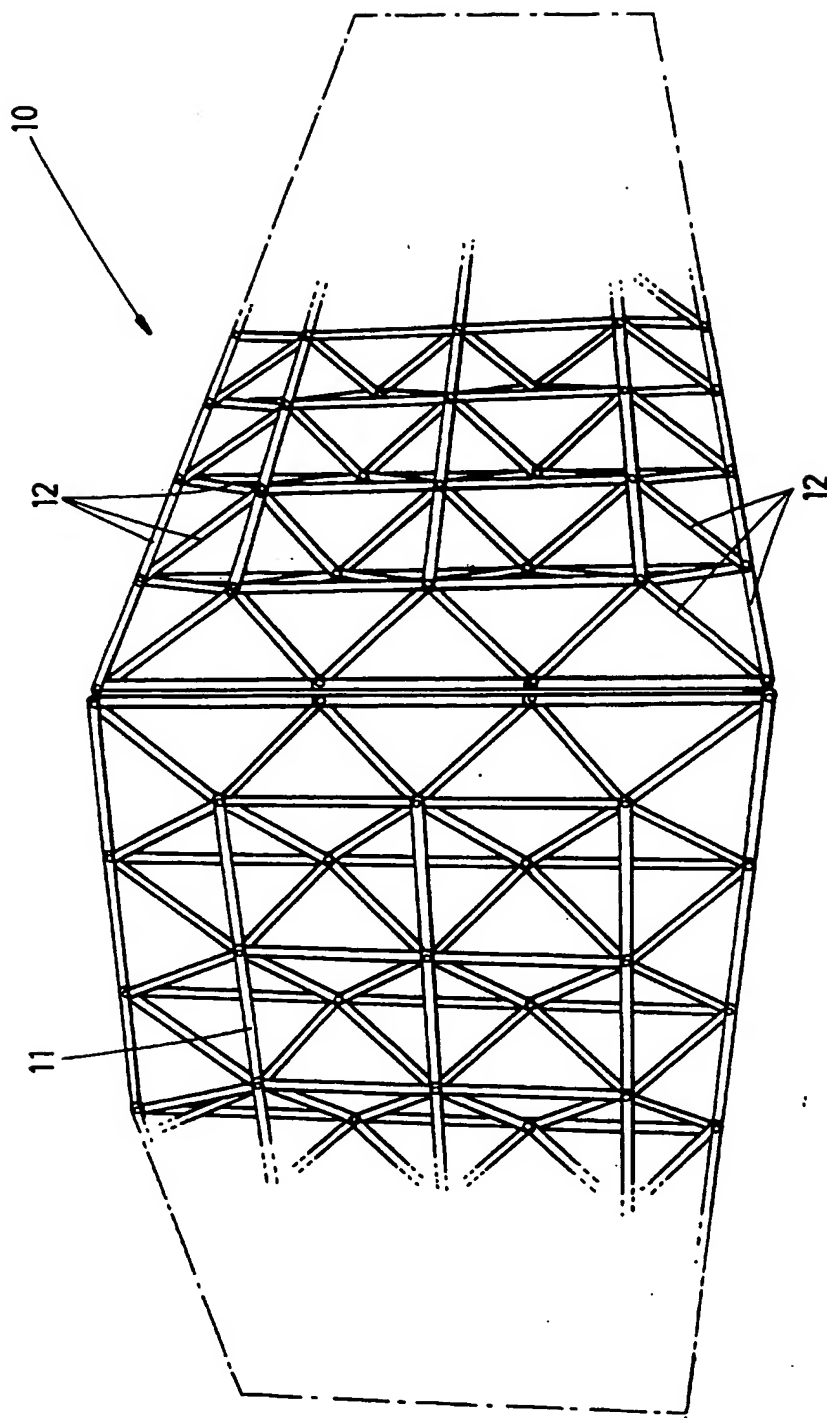
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By his Patent Attorney  
KEN MADDERN



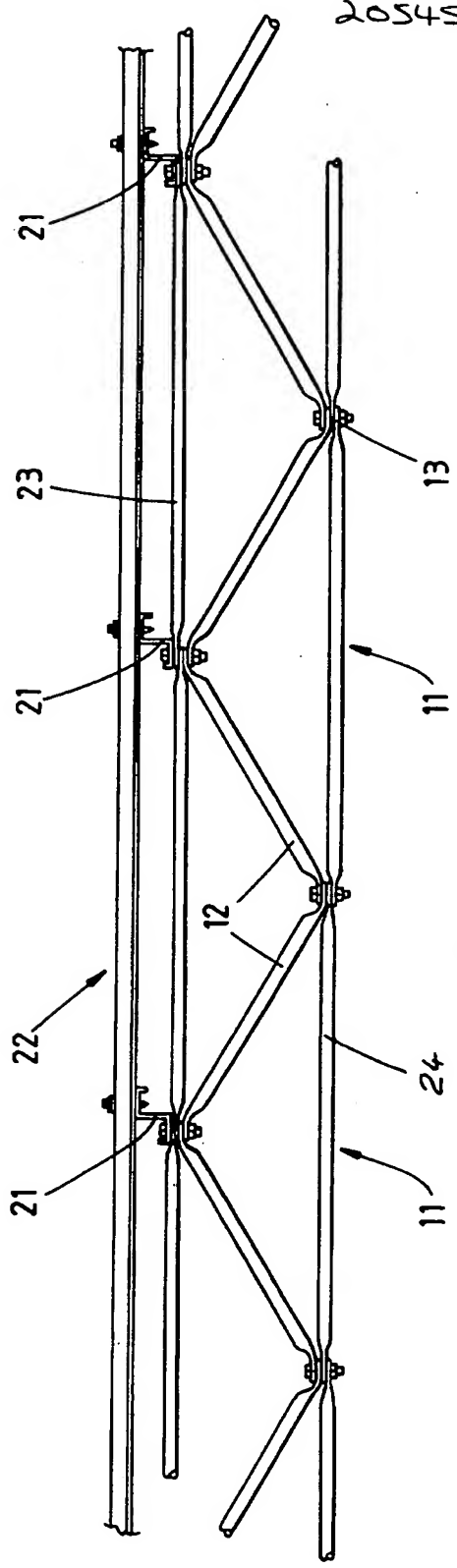
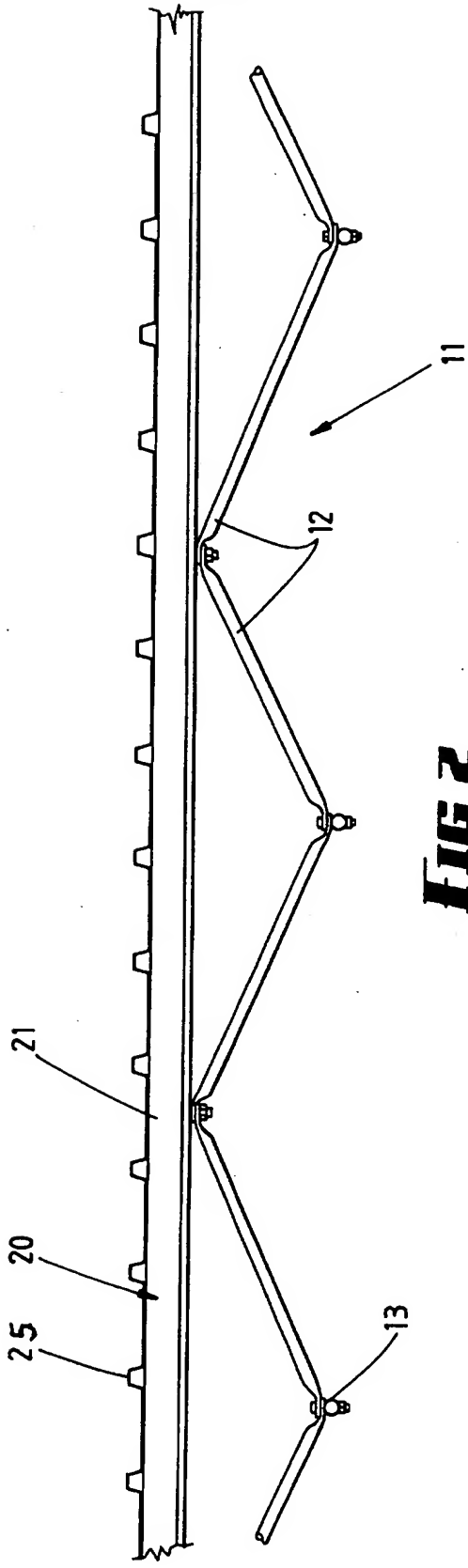
## ABSTRACT

A space frame (11) useable as an alternative to hot rolled structural steel in building construction, wherein an array of relatively flexible beams (20) without bottom structural chords are intersected by relatively rigid trusses (22) with both top and bottom chords, the structure thereby having a degree of flexibility which can accommodate variations in tolerances, dimensions and shape occurring in manufacture, erection, ground movement and temperature differentials. Lower inclination angles of truss struts (12) impose high forces on node points (13), but these are accommodated by clamping together frusto-conical portions (17) of flattened ends (16) of tubular struts, and deforming the edges of the flattened ends (16) to form spacer ribs (18).

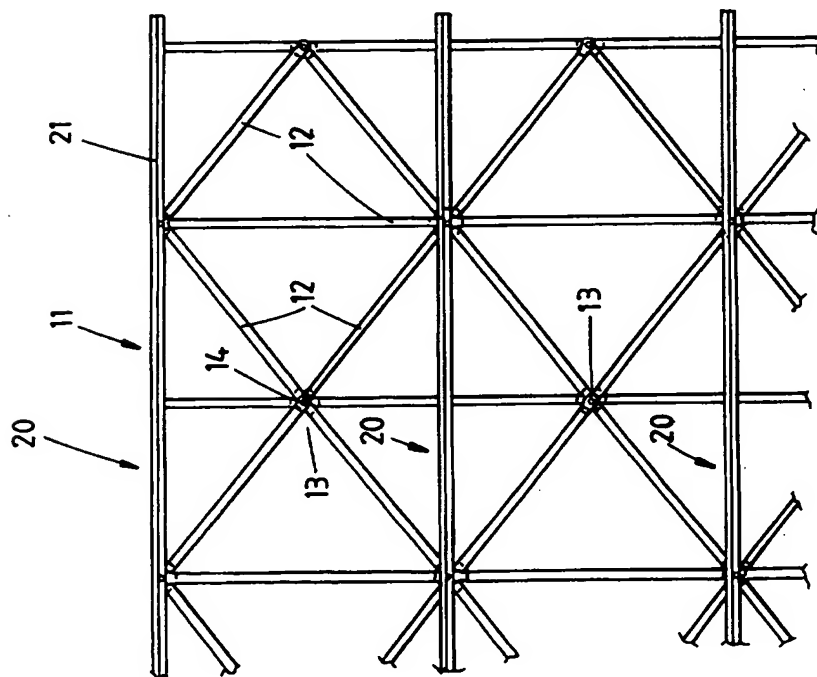
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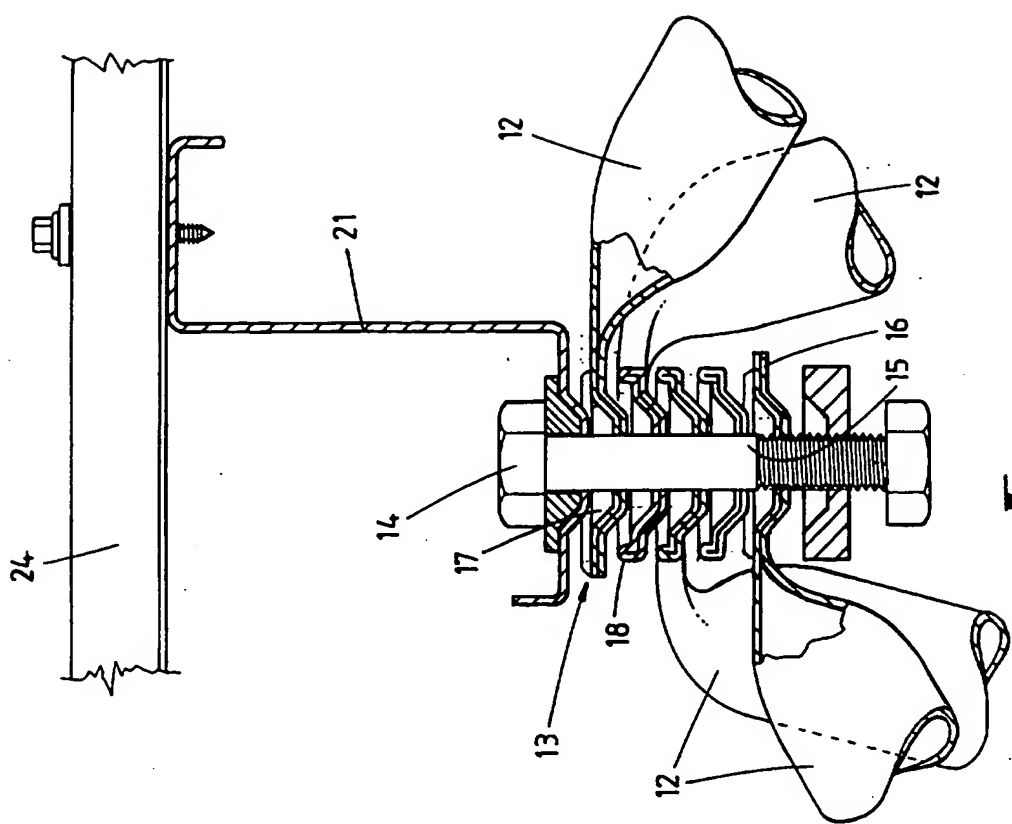
**FIG 1**



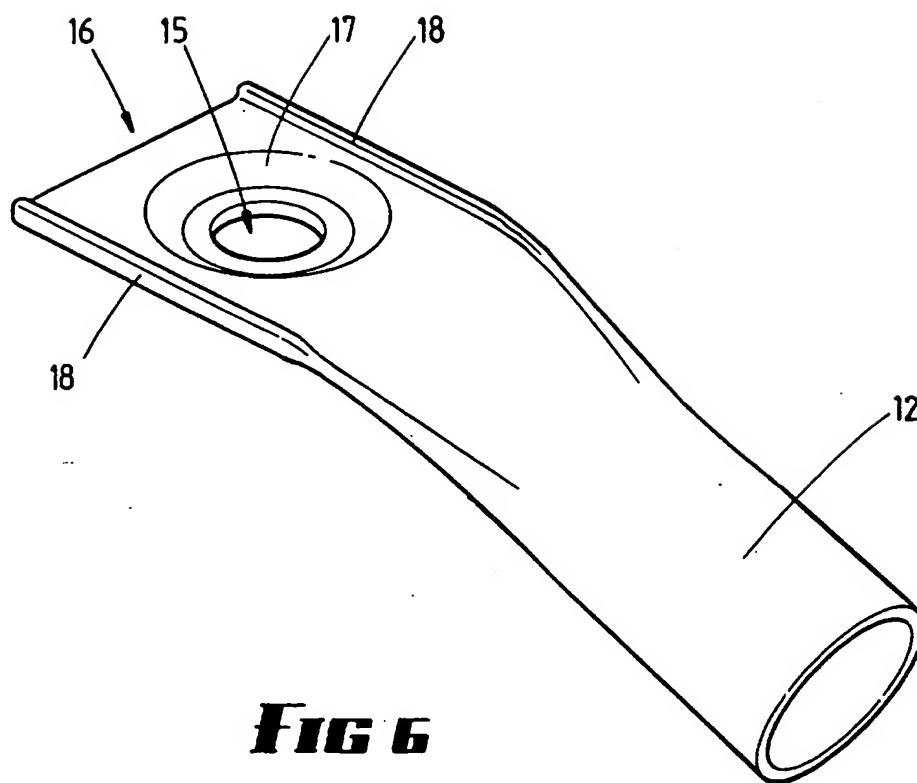
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**FIG 4**



**FIG 5**



**FIG 6**